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A TENTATIVE TAXONOMY OF HUMAN INTERACTIVE FACTORS IN AIRCRAFT MISHAPS

by

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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

Previous research and the results of the present study lend support to the concept of developing a taxonomy of factors or causes in aircraft mishaps. Twenty-five years of mishap research related to psychophysiological and environment l factors was reviewed to determine the most frequently occuring variables. Twenty-one of these were identified and classified into a tentative taxonomy under three functions: Equipment - Physical

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20. Abstract

Environment, Management System, and Operator. Sixteen definitions related to these factors were available to analyze for reliability and relationship to the taxonomy functions.

A survey form was developed which included the above definitions and nine selected aircraft mishap summaries. This instrument was administered to a Flight Safety Officer School class and a group of naive subjects of equivalent age and years of education. The task to be performed was to rate the presence or absence of these "causes" in each of the mishap summaries. Data analysis performed included the computation of mean agreement rates, inter-case consistency, intercorrelations of selected variables, and comparison of mean agreement rates and judged clarity of the definitions.

The results indicate that these factors fit logically into the proposed taxonomy. Discipline Breakdown, Equipment Malfunction, Event Proficiency, and Inadequate Briefing are generally adequate definitions as presented in this study. Channelized Attention and Distraction are closely related and need more specificity to differentiate them. Command and Control, Inadequate Training, Lack of Experience, Lack of Knowledge, Overcommitment and Skill/Technique should all be revised to improve their reliability and clarity. Due to problems in developing observable criteria for judging Mission Stress, Personal Stress, Pressing, and Overmotivation, their current usefulness in mishap research is open to question.

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It would have been impossible to complete this study without the assistance of several persons at the Air Force Inspection and Safety Center. Dr. Anchard F. Zeller was very helpful in the conceptual and design stages. Lieutenant Colonel John Alberts provided vital information for the content and design of the instrument used. Colonel Warren L. Busch was most cooperative in arranging the completion of the instrument by the January 1980 Flight Safety Officer School Class.

Finally, the writer is indebted to Major Stan Santilli of the U.S.A.F. School of Areospace Medicine. His parallel studies in this area provided both insight and encouragement in this research.

CONTENTS

A TENTATIVE TAXONOMY OF HUMAN INTERACTIVE FACTORS IN AIRCRAFT MISHAPS

INTRODUCTION

Background

According to Zeller (13) the major aircraft mishap rate in the U.S. Air Force has decreased dramatically since World War II. In 1943 the rate per 100,000 flying hours was 64. In 1947, when the Air Force was established as a separate service, the rate was down to 44. At the end of the 1970's the rate hovered at about 3 (a reduction factor of 21 since 1943), and has been near that level for approximately a decade. Additionally, since 1947 fatal mishaps have been reduced by a factor of 6 and destroyed aircraft by a factor of 7. Both of these rates also appear relatively constant over the past ten years, with little change toward improvement.

Davis (6) has suggested that the major improvement in reduced mishap rate has been in the hardware area, but it is probable that improved selection and training have also had an effect. In fact, Zeller (13) contends that the human factor causation aspects have decreased as dramatically as material and other considerations. Historically, human error has been attributed in one-half to two-thirds of all mishaps, and continues at that level today. Of these human errors, poor technique in flight, maintenance error, and various supervisory unsafe acts are the three major categories.

Considering the current low rate of mishaps and the apparent constancy of human error involvement, one might ask whether or not the limit in mishap prevention has been reached. At present, no good answer to that question is available. A prime reason for this is that approximately 25 years of research in human factors data related to mishaps has failed to produce a complete and cohesive system for identifying the second order factors or "whys" of human error mishap causation. In general, this failure to find a cohesive system may be due to the limitations of the existent mishap report data. In most studies the source of data has been analysis of individual accident reports or the computer bank data stored at the Air Force Inspection and Safety Center. The computer bank data are elements translated from the individual accident reports by analysts using the coding contained in AFISC Manual 127-1, Aircraft Accident and Incident Classification Elements and Factors (2) and AFISC Manual 127-6, Life Sciences Accident and Incident Classification Elements and Factors (3). Different approaches to analysis of this data has also inhibited the comparison of various studies for the purpose of developing a cohesive system. However, one cannot fault researchers for attempting new approaches. Davis (6) has succinctly stated the present limitations in mishap research in the following:

> . . . The current data bank of abstracted Air Force reports includes only what might be described as primary causes. Second level, or root, causes

> are normally not included. At best, root causes are available only as a result of tedious analysis of the full reports themselves. . . . These are some of the facts of life which research and ISD personnel should be aware of when relying on current accident reports and data banks. . . Although some feel that the human factors problem cannot be dealt with any more effectively than at present, unless we face this challenge we'll never know whether progress in this area is possible or not. (pp. 57-58)

The early research of the 1950's has been summarized by Webb and his associates (11). Briefly, they found only about one-third complete agreement on underlying causation using their own classification system. Since the mid-1950's, research studies on human factors in aircraft mishaps have tended to focus on two general areas: "unsafe acts" as describes in AFISC Manual 127-1, pp. 47-70; and "psychophysiological and environmental factors" found in AFISC Manual 127-6, pp. 8-1 through 8-4. In 1956, Moseley (8) abstracted similiar information from individual reports of 2400 pilot error mishaps and found errors as the result of knowledge, training, experience, attention, excessive motivation, and supervision were the most frequent basic causes. A seeming hiatus of research studies in this area occurred over the next 15 years, possibly due to tediousness of abstracting information from individual mishap reports and the non-availability of computer bank data until the early 1970's. During the 1970's Belk (5), Lewis (7), Ricketson, et. al. (9), Santilli (10), and Wegner (12) have studied similar data covering almost a decade of Air Force and Army Aviation mishap reports.

"Unsafe Acts" data (AFISC Manual 127-1) have proved to be useful as descriptive or "what happened" information, but not as useful in describing "why it happened." Thus the primary current information related to human error second order causes appears to be contained in the "psychophysiological and environmental factors" (AFISC Manual 127-6, and reported by the mishap boards on Air Force Form 711 GA, p. 2). These factors are in joint use by all three armed services in their reporting systems.

Unfortunately, there is one major impediment to interpreting these psychophysiological and environmental factors. The writer was unable to find any official Air Force regulation or manual that defined the terms used. Some environmental variables such as heat, cold, or wind blast are self-evident. On the other hand, such psychophysiological variables as "excessive motivation to suceed" are less generic and require some definition for precise ju gment. Despite this limitation a number of variables occurred frequently in the studies cited above, suggesting their importance for future study.

The problem of organizing information on human factors in mishap causation have been addressed by Santilli (10) and Zeller (13). Zeller has described a scientific approach to systematic analysis of the design parameters of both man and machine and the interface variables between them. In this dynamic closed feedback system man's activities are a series of perception/decision/response activities. He suggests

that a number of variables in man's design should be examined for their potential contribution to human error. These are the physical, physiological, psychological, psychosocial and pathological strengths or limitations. In his model the mishap occurs when the level of demands placed on man increase to intersect with a decreasing level of capability to meet them. Santilli modified this concept into an environmental/organism model. The environment consists of all varibles with which the organism must cope (machine, weather, supervision, and mission). The organism includes the variables described above by Zeller. Both of these approaches assume the operator as a central focus, with the premise that the analysis of the operator's interaction with the machine and environment provides the most useful information on mishap causation and prevention.

Purpose and Scope

The original objectives of this study were to develop a method of determining the relative contribution of various personnel to mishaps, and to determine the feasibility of developing a taxonomy of framework for analysis of human error in mishaps. These two general objectives remained the same, but certain factors intervened to modify the scope and approach used. One of these was the appearance of the San tilli (10) and Zeller (13) papers subsequent to the submission of the proposal. These papers suggested different directions for the development of a taxonomy. Secondly, for reasons outlined in the background section

of this report, the utilization of unsafe act data from the AFISC computer bank did not appear to be a useful approach to developing a taxonomy. Essentially the unsafe acts are "what" rather than "why" data. This is not to deny the importance of this data in a general taxonomy of mishap information which might be developed later. However, the limitations of time and money dictated a modified scope and approach. In collaboration with Dr. Zeller it was decided to focus on second order causes, their value as descriptive terms, and their "fit" into a potential framework or taxonomy of human error in mishaps.

The scope of this study was limited in several ways. First it was decided to consider only those variables that had been found to occur frequently in previous studies. Secondly, the variables selected would have to be adequately defined to be useful in this study. The only available definition sources were the Santilli study (10) and those derived by Lt. Col. John Alberts and his associates at AFISC. These two sources were considered the most valid available, since the definitions provided were based on the best available combination of both flying experiences and mishap data analysis. Lt. Col. Alberts also supplied the mishap cases or summaries used in this study, which he and his associates wrote for Change Pace Analysis (1). He provided many more cases than were required, and those used were ones which exemplified the factors studied. In sum, this study

was limited to the most frequently occurring variables in previous research, those with reasonably adequate definitions, those which were readily identifiable in specially developed mishap summaries, and those which could be incorporated into measurement instrument of reasonable length and complexity. Thus a limited number of second order causes were studied. There are possibly many more that could be developed and studied. This is merely a first step in organizing and validating an approach to a taxonomy or framework for human error interaction in aircraft mishaps.

Approach

The approach taken here was two-fold. The first purpose was to try to develop a logical framework, taxonomy, or model for organizing the variables to be studied. The most recent efforts in this direction are outlined in Santilli (10) and Zeller (13). Some elements of each of these were included in a tentative modified model.

An outline of a tentative taxonomy of frequently occurring factors in aircraft accidents is presented in Table I. The table is divided into three major parts, representing interacting functions in aircraft mishaps: Equipment-Physical Environment, Management System, and Operator. Each function has subdivisions representing related factors within it. The 21 most frequently occurring variables or factors in previous studies are listed with their code numbers and identical phrasing as they appear on Air Force Form 711, GA, p.2.

The phrases in parentheses next to each factor are the titles of the definitions used in this study that are most closely associated with the listed factors.

This framework or taxonomy was adapted primarily from Santilli (10) and Zeller (13). Figure 1. presents the relationship between the three major elements of this concept. The prime difference between this concept and Zeller's is that the management system contains the primary factors in the interface between the operator and the equipment - physical environment. The major premise of this model is that the operator is continuously interacting with the equipment and physical environment, but primarily through the medium of the management system. Thus the management system prepares both operator and equipment, plans the interaction of both together and makes decisions about missions and environmental elements under which they will be performed. Santilli's (10) approach deals with similar variables but places them in two categories, environmental and operator. Table I has divided his environmental variables into equipment - physical environmental functions and management system functions.

As can be seen from Table I not all of the listed factors were included in the experimental study. The main reasons for exclusion were non-availability of a definition or appropriate mishap summary, or limitations in the length of the survey instrument used. Table II

TABLE I

TENTATIVE TAXONOMY OF FREQUENTLY OCCURRING FACTORS IN AIRCRAFT MISHAPS

EQUIPMENT-PHYSICAL ENVIRONMENT FUNCTION

Equipment

403 Failure, Instruments/Controls (Equipment Malfunction)

Physical Environment

710 Visual Restrictions-Weather, Haze, Darkness

MANAGEMENT SYSTEM FUNCTION

Training

301 Inadequate Transition (Inadequate Training, Lack of Experience, Lack of Knowledge)
303 Limited Recent Experience (Event Proficiency)
304 Failure to use Accepted Procedures (Skill/Technique)

Supervision

101 Inadequate Briefing (Inadequate Briefing)
102 Ordered/Led on Flight Beyond Capabilities (Overcommitment)
103 Poor Crew Coordination

OPERATOR FUNCTION

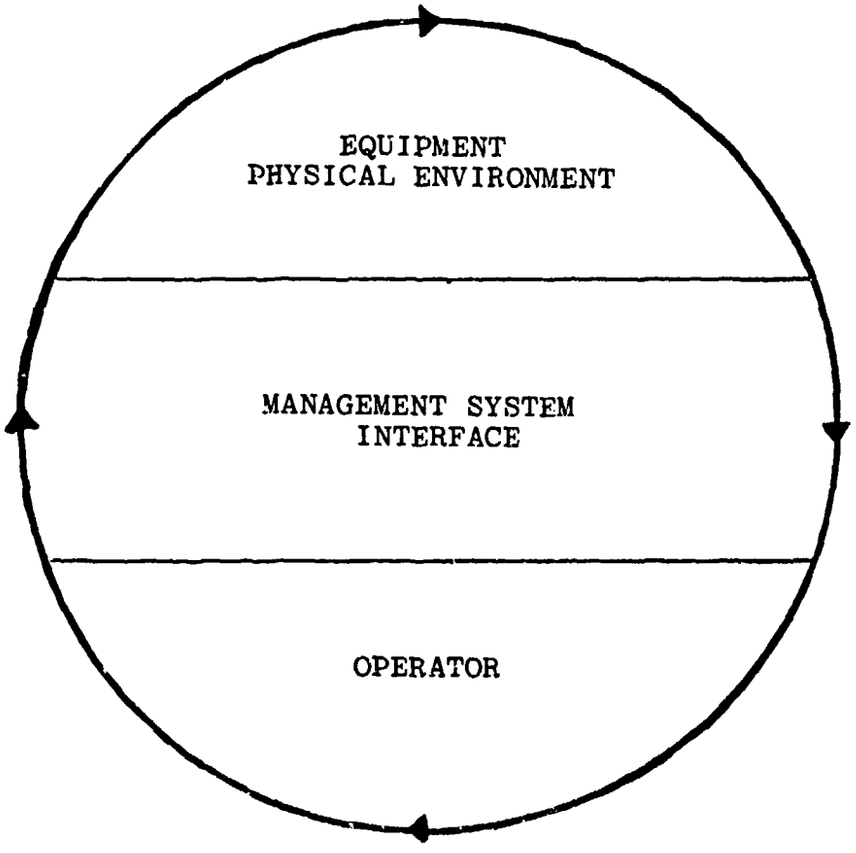
Physical/Physiological

615 Disorientation/Vertigo
808 Inadequate Coordination/Timing

Psychological/Psychosocial

621 Inattention
622 Channelized Attention (Channelized Attention)
623 Distraction (Distraction)
625 Excessive Motivation to Succeed (Overmotivation)
626 Overconfidence (Pressing)
801 Habit Interference
807 Task Oversaturation
809 Misjudged Speed or Distance
810 Selected Wrong Course of Action
811 Delay in Taking Necessary Action
812 Violation of flight Discipline (Discipline Breakdown)

RELATIONSHIP BETWEEN TAXONOMY ELEMENTS



CONTINUOUS FEEDBACK TIME FLOW

FIGURE 1.

presents the second order factors used in the experimental study. Definitions of the 16 causes are presented in the appendix. Three second order causes that do not appear in Table I were selected for use in the experimental study. Command and Control and Mission Stress were found to be significant variables by Santilli (10). Their definitions were developed by Lt. Col Alberts at AFISC to describe causation in many of the mishap summaries provided by him. Personal Stress is another concept developed by Alberts, and appears most similar to Preoccupation with Personal Problems (624) on Air Force Form 711 GA, p.2. It was not a high frequency occurrence in other studies of Air Force Form 711 GA, p.2.

The establishment of the above taxonomy or framework provides a context for the study of individual second order causes. In the experimental part of this research it was decided to focus on these basic elements of the taxonomy. The major reason for this is that although Santilli and Alberts have developed authoritative definitions of these causes, they are not yet in use by mishap boards. Before they might be placed in widespread use some evaluation of their reliability seemed necessary. Across the various studies of causes it appears that different researchers have been using different terms to describe the same or overlapping concepts of causes. Reasonably precise, uniform definitions of causes are necessary if research findings are to produce practical recommendations for

TABLE II

TENTATIVE TAXONOMY OF DEFINITIONS
USED IN EXPERIMENTAL STUDY

EQUIPMENT-PHYSICAL ENVIRONMENT FUNCTION

Equipment
- Equipment Malfunction

MANAGEMENT SYSTEM FUNCTION

Training
- Event Proficiency
- Inadequate Training
- Lack of Experience
- Lack of Knowledge
- Skill-Technique

Supervision
- Command and Control
- Inadequate Briefing
- Overcommitment

OPERATOR FUNCTION

Psychological/Psychosocial
- Channelized Attention
- Discipline Breakdown
- Distraction
- Mission Stress
- Overmotivation
- Personal Stress
- Pressing

improvements in flight safety. Perhaps more importantly, uniform definitions, not currently available to mishap boards, are a prerequisite to the input of accurate information into mishap investigation reports. Establishing the reliability of some of these definitions of causes was the task of the following study.

METHOD

The general method used in this study included the development of an appropriate survey instrument, administering it to two samples and analyzing the results for reliability and comparability.

Instrumentation

A survey instrument containing sixteen definitions of causes of aircraft mishaps to be applied to nine mishap summaries was developed for this study. The sixteen causes used are listed in Table II and defined in the appendix. The instructions for completing the form and an example of the cases or mishap summaries is also included in the appendix. The definitions and summaries were edited versions of those presented in Santilli (10), Change Pace Analysis, 21 August 1978 (1), and USAF Destroyed Aircraft Analysis (Addendumto Change Pace Analysis, 21 August 1978) (4).

The causes used were generally restricted to those associated with the psychophysiological and environmental factors of AF Form 711 GA,

p.2. which were most frequently cited in previous studies. Another restriction was the availability of a reasonably well developed definition of the cause. The definitions found in the appendix were composed of revised and combined definitions found in the studies cited above. The editorial changes were aimed at producing a briefer, more precise, and clearer definition. No claim is made as to the perfection of these definitions, only that they were the best available at the time. A final restriction on the definitions used was the practical factor of length of the instrument.

The cases or mishap summaries were selected using similar criteria. A variety of bomber, cargo, fighter, and trainer cases were used, with most being fighters (the overwhelming majority of mishaps). The cases were limited to nine, to keep the instrument length reasonable. In addition, an attempt was made to include at least two cases with which each second order cause should be associated. There was one variation in this selection procedure. There is no true indication of Equipment Malfunction in any case. However, there are two cases in which some subject might see Equipment Malfunction. This cause was inserted to determine the upper level of reliability of response that might be expected from the group of subjects. It has been shown in previous studies that subjects are more consistent in determining the lack of presence than the presence of a factor. All cases were edited to eliminate or clarify

Air Force abbreviations and jargon for use with unsophisticated subjects.

The process of completing the survey required the subject to study the definitions and then determine the degree to which each cause was definitely, possibly, or not present in each case. Respondents were permitted to review the definitions at any time, and were advised that not all causes occur in all cases. At the end of the survey the subject is asked to rate each definition as very clear, somewhat clear, or very vague, and to comment on their usefulness.

Subjects

Two groups of subjects were used in this study. One was a group of graduate students in psychology. There was no need or desire to sample a broad population for the purpose of this study. These subjects were chosen because they represented an unsophisticated (technically) group of an approximate age and educational level of persons who might be expected to perform such an analysis in real life. The second group was the January 1980 class of the Flight Safety Officer School at the Air Force Inspection and Safety Center. These are persons who might be expected to perform similar tasks as members of a mishap investigation board. This sample was chosen to provide a group that would have some

sophistication in the operational areas, if not in mishap investigation. The premise behind selection of the subjects was to determine whether or not the definitions of causes had sufficient clarity of meaning to persons of different levels of sophistication. Ideally, a cause definition should be clear enough to be commonly understood by anyone who might have official access to a mishap report.

Procedures

The instrument was administered as follows. The Graduate Students in Psychology (GSP hereafter) were asked to volunteer to take the instrument home complete it, and return it as soon as possible. Over a two month period 27 were returned. Two were not included in the study because the respondents failed to complete a page of the instrument. The Flight Safety Officer School students (FSO hereafter) were administered the instrument during class time at the Air Force Inspection and Safety Center. Twenty six FSO returns were received. One was not included in the study due to failure to complete the last page of the instrument. Since anonymity was assured in both samples, it was not possible to secure completion of the instrument by those who failed to do so.

The subjects were asked to indicate their age, sex, and years of education, and their responses directly on the instrument. This information was transcribed directly on to optical scan answer sheets by the researcher for data processing. These answer sheets were

then scanned and translated onto computer tapes for data processing.

RESULTS

Age, Sex, and Years of Education

This data for the two samples were compared for possible differences. Table III presents the means and standard deviations. All of the FSO group were male, while 64 per cent of the GSP group was female. The FSO group averaged 1.2 years older than the GSP group, while the GSP group averaged about one third of a year more education. F-ratios revealed no significant differences between males and females or between the FSO and GSP groups in age or years of education.

Development of Instrument Key

In order to determine the reliability of response to the instrument, it was necessary to develop a key to score the subject's responses. Since the two samples did not differ in age or years of education, they were combined for the purpose of determining their degree of agreement on responses to each item. One hundred forty four items (9 cases times 16 definitions) were analyzed for direction and degree of significance of agreement (in excess of change) through use of the chi-square statistic. The first column of Table IV lists the number of items for which there was a significant chi-square value at the .05 level or above.

TABLE III

AGE, SEX, AND YEARS OF EDUCATION
OF GSP AND FSO SAMPLES

	GSP(N=25)						FSO(N=25)	
	MALE		FEMALE		TOTAL			
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
AGE	30.00	5.89	29.81	8.83	29.88	7.89	31.08	7.07
YEARS OF EDUCATION	16.78	.99	17.75	.97	17.08	1.02	16.72	1.49

TABLE IV

NUMBER OF ITEMS SIGNIFICANT AT THE .05 LEVEL OR ABOVE (CHI SQUARE) FOR EACH DEFINITION

		Significant in Total Group	Significant in GSP or FSO Only	Total Items Significant
1.	Channelized Attention	8	1	9
2.	Command and Control	6	1	7
3.	Discipline Breakdown	8	1	9
4.	Distraction	7	1	8
5.	Equipment Malfunction	9	0	9
6.	Event Proficiency	7	2	9
7.	Inadequate Briefing	7	1	8
8.	Inadequate Training	6	0	6
9.	Lack of Experience	9	0	9
10.	Lack of Knowledge	4	2	6
11.	Mission Stress	7	0	7
12.	Overcommitment	5	0	5
13.	Overmotivation	6	1	7
14.	Personal Stress	9	0	9
15.	Pressing	4	0	4
16.	Skill/Technique	6	1	7
		108	11	119

In order to improve the validity of the scoring procedures chi squares were computed on the separate GSP and FSO group responses to those items that were not significant for the total group. From the second column in Table IV it can be seen that 11 more items were found significant using this approach. This produced a total of 119 significant items of the 144 total. The subjects had the most difficulty in agreeing to a significant degree on the presence or absence of Inadequate Training, Lack of Knowledge, Overcommitment, and Pressing across the cases. The 25 items not found to be significant were keyed "Possibly Present" for purposes of further analyses. The rationale for this was that Possibly Present essentially a neutral response, and keying in this direction would not significantly increase or decrease the subsequent reliability calculations.

Agreement Rates and Consistency

One method of testing the reliability of subject responses is to determine average proportion of agreement. This was done by calculating the mean proportion of agreement of the total group to the keyed responses for each definition (across the nine cases). Table V presents these along with standard deviations of proportion of agreement for the nine items of each definition. The inter-case consistency (Kuder-Richardson Formula 20) for the set of nine items representing each definition are also indicated in Table V.

TABLE V

MEAN AGREEMENT RATES AND
CONSISTENCY OF RESPONSE ACROSS CASES (N=50)

	Definition	Mean Agreement Rate	Standard Deviations	Inter-Case Consistency
1.	Channelized Attention	60.9*	11.6	.46 A
2.	Command and Control	54.9*	8.2	.37 A
3.	Discipline Breakdown	66.1*	16.6	.44 A
4.	Distraction	52.2*	8.3	.02 L
5.	Equipment Malfunction	78.7*	12.2	.69 VH
6.	Event Proficiency	58.4*	16.0	.27 A
7.	Inadequate Briefing	60.1*	16.9	.35 A
8.	Inadequate Training	60.7*	18.8	.06 L
9.	Lack of Experience	70.7*	17.9	.01 L
10.	Lack of Knowledge	51.8**	21.8	.15 L
11.	Mission Stress	56.0*	17.7	.13 L
12.	Overcommitment	43.6	12.1	.60 VH
13.	Overmotivation	49.3**	11.4	.23 L
14.	Personal Stress	70.0*	9.3	.61 VH
15.	Pressing	41.1	17.0	.15 L
16.	Skill/Technique	48.4**	5.6	.10 L

* .01 level of significance above chance agreement
** .05 level of significance above chance agreement

L Low to Not Significant
A Acceptable
VH Very High

To interpret the mean agreement rate, it is important to remember that a 33 1/3 rate would indicate that the average response rate was at the chance level. With this data, a 47 percent agreement rate is significantly above chance at the .05 level, and 52 percent agreement rate is significant at the .01 level of confidence. Thus the mean agreement rates for Overcommitment and Pressing are not significantly above chance, and those for Lack of Knowledge, Overmotivation and Skill/Technique would be considered low. Also, in interpreting the size of the mean agreement rates several considerations must be kept in mind. For most of the definitions with agreement rates below 52, there was a strong tendency for the respondents to select Possibly Present across the nine cases. The converse was true for those definitions with agreement rates above 52. This suggests that a high level of agreement also represents a high level of definiteness about the presence or absence of a cause within the cases presented.

The inter-case consistency column in Table V lists Kuder-Richardson Formula 20 coefficients across the nine cases for each definition. These indicate the consistency of the subjects in responding to the presence or absence of a cause in each of the cases. Although there is no set standard for judging the size of these coefficients, with only nine cases these values might be rated as follows. (It is unusual to find KR-20 values above .50 with nine cases):

.50+	Very High
.25 - .49	Acceptable
.00 - .24	Low to Non Significant

The subjects were most consistent in their responses to the presence or absence of Equipment Malfunction, Overcommitment, and Personal Stress. At the other end of the scale they lacked consistency across cases in responding to Distraction, Inadequate Training, Lack of Experience, Lack of Knowledge, Mission Stress, Overmotivation, Pressing, and Skill/Technique. Acceptable levels of consistency were found for Channelized Attention, Command and Control, Discipline Breakdown, Event Proficiency, and Inadequate Briefing.

To properly interpret Table V, it is important to use both the mean agreement rate and inter-case consistency in combination for each definition. In general, mean agreement rate above 52 combined with an inter-case consistency coefficient above .25 suggests a reliable and valid definition. Channelized Attention, Command and Control, Discipline Breakdown, Equipment Malfunction, Event Proficiency, Inadequate Briefing; and Personal Stress meet these dual criteria. The other definitions may be considered to have low to moderate reliability.

The low inter-case consistencies found for half of these definitions suggest that caution be used in interpreting agreement rates as measures of reliability in this and other studies. The definitions with low inter-case consistencies were generally those that were least precise and/or overlapped with others. Ambiguous definitions are unlikely to be useful

even to well-trained, expert raters.

Clarity of Definitions

The last page of the instrument asked the subjects to estimate the clarity of the definitions in terms of whether they were very clear, somewhat clear, or very vague. Respondents were also asked to comment on the usefulness of each definition. Mean clarity ratings were calculated for each scale and rank-ordered. These were then correlated with the rank order of mean agreement rates for each scale. These rankings are shown in Table VI. The correlation of .722 indicates a high level of correspondence between the respondents' estimates of clarity of the definition and their ability to detect the absence or presence of the "causes" in the cases. The major discrepancies in these rankings occured for definitions of Distraction, Inadequate Training, Lack of Experience, and Pressing. For Distraction and Pressing the clarity ranks were higher than the ranks for agreement rates. For Inadequate Training and Lack of Experience, the opposite was true.

Interrelationships Between Definitions

Eleven subjects volunteered 37 comments pertaining to all of the definitions except Equipment Malfunction. Many of the comments duplicated each other and 24 were focussed on overlap between definitions. Interestingly enough, these suggestions of relatedness paralleled the tentative taxonomy

TABLE VI

RANK ORDER OF MEAN AGREEMENT RATES AND MEAN CLARITY RESPONSES (N=50)

	Mean Agreement Rank	Mean Clarity Rank
Channelized Attention	5	2
Command and Control	10	11
Discipline Breakdown	4	3.5
Distraction	11	5.5
Equipment Malfunction	1	1
Event Proficiency	8	10
Inadequate Briefing	7	9
Inadequate Training	6	12
Lack of Experience	2	5.5
Lack of Knowledge	12	14
Mission Stress	9	8
Overcommitment	15	16
Overmotivation	13	15
Personal Stress	3	3.5
Pressing	16	7
Skill/Technique	14	13

Rank Order Correlation .722

proposed in Tables I and II (e.g., Inadequate Training is similar to Event Proficiency, Lack of Experience, Lack of Knowledge, and Skill/Technique). The general content of the other 13 comments is incorporated into the discussion of conclusions and recommendations of this report.

Several correlational hypotheses related to the tentative taxonomy and the subjects comments were generated. Under the Management System Function it was hypothesized that:

Ho 1. Event Proficiency, Inadequate Training, Lack of Experience Lack of Knowledge, Overcommitment, and Skill/Technique are significantly intercorrelated.

Ho 2. Command and Control and Inadequate Briefing are significantly correlated.

Under Operator Function it was hypothesized that:

Ho.3. Channelized Attention and Distraction are significantly correlated.

Ho 4. Discipline Breakdown and Pressing are significantly correlated.

Ho 5. Overcommitment, Overmotivation and Pressing are significantly intercorrelated.

The 21 correlations related to these hypotheses are shown in Table VII. Those between Inadequate Training and Lack of Experience (.364), Lack of Experience and Lack of Knowledge (.359), and Inadequate Training and Overcommitment (.294) were significant at the .05 level, and that between Lack of Knowledge and Overcommitment (.369) was significant at the .01 level with the total group. The same correlations were also computed for the GSP and FSO samples separately. None reached

TABLE VII

INTERCORRELATIONS OF RESPONSES TO SELECTED DEFINITIONS (N=50)

	2	3	4	6	7	8	9	10	12	13	15	16
1. Channelized Attention			.245		-	-	-	--	--			
2. Command & Control					-.074						-.098	
3. Discipline Breakdown											-.263	
4. Distraction												
6. Event Proficiency						.170	.142	.083	-.085			.000
7. Inadequate Briefing												
8. Inadequate Training							.364**	.230	.294**			.165
9. Lack of Experience								.359**	.231			.130
10. Lack of Knowledge									.369*			.261
12. Overcommitment										.177	.052	.060
13. Overmotivation											.096	
15. Pressing												
16. Skill/Technique												

* Significant at the .01 level

** Significant at the .05 level

significance in the GSP group. However, in the FSO group, the correlations between Channelized Attention and Distraction (.452), Inadequate Training and Skill/Technique (.415), and Lack of Knowledge and Overcommitment (.487) were significant at the .05 level.

These results tend to support Ho 1 and Ho 3 but not the others. Inadequate Training, Lack of Experience, Lack of Knowledge and Overcommitment all appear to fit logically together under Training of the Management System Function in the tentative taxonomy (Tables I and II). Overcommitment was perceived as more related to Training than Supervision. Event Proficiency appears to be a more specific factor under Training. The FSO group also saw Skill/Technique as related to Inadequate Training. Finally, the FSO group also tended to associate Channelized Attention with Distraction in the cases. This suggests that these two definitions both fit under a general factor of concentration.

CONCLUSIONS AND RECOMMENDATIONS

The results of this research indicate that the definitions studied have varying degrees of reliability and usefulness in describing aircraft mishap causes. In the following, they will be discussed in terms of their relationship to the tentative taxonomy proposed in Tables I and II.

Equipment - Physical Environment Variables

Equipment Malfunction is actually a first order factor in that it specifies what happened rather than why. It was used in this study to establish the upper level of agreement rate and inter-case consistency that might be expected for the subjects. The 78.7 mean agreement rate (89 in the FSO group) and .69 inter-case consistency coefficient were the highest for any definition, indicating that it did serve this purpose well. Also, this definition was ranked as the most clear. Recommendation: This definition could be improved by specifying whether equipment malfunction is operator induced or due to other reasons.

Management System Variables

Eight definitions were studied under the category of management system function.

Event Proficiency had a relatively high mean agreement rate and an acceptable level of inter-case consistency. It is not significantly related to other training factors. This definition also ranked high in terms of clarity. Recommendation: No recommendation for improvement of this definition is made.

Inadequate Training had a high mean agreement rate but very low inter-case consistency and clarity ranking. Its positive correlations with Lack of Experience, Lack of Knowledge, Overcommitment and Skill/Technique suggests that raters consider them to be associated

concepts. It is also possible that degree of training and experience are perceived as relatively indistinguishable concepts. For example, during peacetime, training missions constitute the majority of in-flight experiences for crew members in combat aircraft.

Recommendation: Inadequate Training should be combined with Lack of Experience. A minimum standard of training/experience adequate to safely perform a mission element should be added to permit more precise judgment of this factor.

Lack of Experience. The preceding comments about Inadequate Training fit this definition also. Indication of a 200 hour minimum probably influenced the relatively high clarity rating, but the inter-case consistency was very low. One subject suggested using the specific Air Force Command directives on training/experience to establish minimal standards in this area. Recommendations: This definition should be revised to include a more appropriate minimum standard of experience.

Lack of Knowledge. Again this definition was seen as related to Inadequate Training, Lack of Experience and Overcommitment. Both clarity rank and inter-case consistency were very low. Knowledge can be assumed to be the result of training and experience. It is a management responsibility to ensure that a minimal safe level of knowledge is attained or the operator should not be permitted to fly

(except under immediate supervision). The very high positive correlation with Overcommitment suggests these two definitions are redundant or Lack of Knowledge is a special case of Overcommitment. Recommendation: This definition should probably be eliminated or incorporated as a specific case of Overcommitment.

Overcommitment had a low mean agreement rate but high inter-case consistency. It is actually a dual definition as stated in this study. If operators are assigned to a task for which they are not prepared, then the major factor involved is supervision. If operators choose to perform a task for which they are not prepared it is an Operator Function. The low mean agreement rate for this definition suggests that the subjects had difficulty separating the dual elements of this definition. One rater commented that this was actually two definitions: (1) not prepared for the mission, and (2) overtaxing of ability/capacity. In either case the supervisor should not assign an operator to a mission unless minimal safe performance can be assumed. Recommendation: Separate definitions for supervisory overcommitment and operator overcommitment should be established and maintained.

Skill/Technique had a low agreement rate and clarity ranking, and low inter-case consistency. It was significantly correlated with Inadequate Training in the FSO group, suggesting it was perceived as a sub-factor of training. It is a dual definition implying either a lack of

motor skills or failure to use proper technique. Recommendation. This definition should be eliminated as probably redundant to Inadequate Training, or revised as a sub-factor of training.

Operator Variables

The operator functions discussed below are primarily psychological/psychosocial factors that are focused within the individual.

Channelized Attention had a high agreement rate and clarity rank, and acceptable inter-case consistency. Its correlation with Distraction suggests they both fit under a general concentration factor. It is a very clear and specific definition. Recommendation. This definition would probably be more useful for reporting and research if included along with other related definitions such as Distraction and inattention under a general factor of concentration.

Distraction had a high clarity ranking and a good mean agreement rate, but low inter-case consistency. Its correlation with Channelized Attention and comments by the subjects suggest both measure different elements of a general factor of concentration. In fact, both definitions imply a failure to attend to safety related cues due to concentration on other stimuli. Recommendations are the same as for Channelized Attention above.

Discipline Breakdown had a high mean agreement rate and clarity ranking, and acceptable inter-case consistency. It was not

significantly correlated with Pressing. It is a good, clear definition in its present form. Recommendations. None.

Mission Stress had a reasonably high mean agreement rate, but average clarity ranking and low inter-case consistency. One subject suggested that the effect of mission stress varies with the individual, and also the amount of previous exposure to similar situations. The present definition does not provide for these individual differences, and the subjects had difficulty agreeing even though the external criteria of Mission Stress were specified in various cases. Recommendations. Since it is difficult to assess the internal effect of Mission Stress on an individual it might be appropriate to simply record whether or not it was the first deployment, exercise, mission, or check-ride for the operator.

Overmotivation was a relatively weak definition in terms of mean agreement rate and inter-case consistency and clarity. It was not significantly correlated with Pressing. Several subjects suggested that it might be synonymous with recklessness, overaggressiveness, or inability to assess one's own capabilities. The main problem with this definition is that it lacks clarity and specificity. It is difficult to determine at what point motivation to succeed in a mission becomes overmotivation. Recommendation: Improved rating of this factor requires the development of more specific observable criteria for judging degree of motivation.

Personal Stress had a high mean agreement rate and clarity ranking, and high inter-case consistency. However this may be partially discounted since seven of the nine cases had no indication of this factor. Raters are more reliable in judging the absence of a factor than its presence. Historically, Personal Stress (preoccupation with personal problems) has been reported as present in mishap investigation research in only about two percent of cases. The effects of Personal Stress vary with the individual and at present there is no objective way of measuring them. Recommendation. This definition could be used as-is for purposes of reporting presence or absence of personal stress. However, unless a criteria for measuring its effects can be developed it is probably not very useful in mishap research.

Pressing had the lowest agreement rate, low inter-case consistency and an average clarity ranking. It was not significantly related to Overcommitment or Overmotivation, and was negatively correlated with Discipline Breakdown. This suggests that it is very difficult to determine from an accident report or summary whether or not a pilot was "taking a chance." Recommendation. Since this concept is not presently measureable for research purposes, it should be revised or eliminated from the taxonomy.

SUMMARY

Both previous research and the results of this study lend support to the tentative taxonomy of human error interaction outlined in Tables I and II. The intercorrelations found tend to support the idea that Event Proficiency, Inadequate Training, Lack of Experience, Lack of Knowledge, Skill/Technique and Overcommitment are all sub-factors under a general factor of Training. The high significant correlations between Inadequate Training, Lack of Experience and Lack of Knowledge imply that these definitions are not specific enough for raters to distinguish between them well. The results also suggest that Channelized Attention and Distraction are related sub-factors of concentration of attention.

The definitions were analyzed for mean agreement rate, inter-case consistency, and clarity ranking. The results indicated that Discipline Breakdown, Equipment Malfunction, Event Proficiency, and Inadequate Briefing, need little or no revision. Channelized Attention and Distraction are related factors and the subtle differences between them need to be spelled out more clearly. Command and Control could be improved by specifying level and type of supervisory inadequacy. Inadequate Training, Lack of Experience, Lack of Knowledge, Overcommitment and Skill/Technique all need significant revisions to differentiate them from each other. Lack of Knowledge appears to be a sub-category of Overcommitment, and Skill/Technique

a sub-category of Inadequate Training. No precise way of measuring degrees of Mission Stress or Personal Stress as they relate to mishap causation is currently available. Until specific criteria can be developed, these definitions are not particularly useful in mishap research. The definitions of Overmotivation and Pressing have similar problems of lack of specific observable criteria for judging degree of motivation and tendency to "take a chance".

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APPENDIX

Age _____ Sex _____ Years of Education _____

In the following we are asking your cooperation in a study of the definitions of "causes" that might be assigned to aircraft mishap cases. On the next two pages are definitions of a variety of possible "causes". These are followed by several summary descriptions of aircraft mishaps.

Please do the following:

1. Study each of the definitions until you feel they are well in mind.
2. Rate the degree to which you feel each of the "causes" exist in each summary. Not all of the "causes" appear in each summary. You are asked to determine if they are DEFINITELY PRESENT (1), POSSIBLY PRESENT (2), or NOT PRESENT (3), and indicate your judgements as to their degree of presence after each "cause" listed at the end of the summary. Feel free to consult the definitions pages at any time.
3. After you have completed the above, please enter any comments you have on the clarity of each definition and how it might be improved on the last page of this form.

Please keep the following in mind. There are no specific right or wrong answers on this form. We are trying to determine whether or not the definitions and summaries are sufficiently clear that a variety of people can make reasonable judgements about them.

We thank you for your cooperation on behalf of the Air Force Inspection and Safety Center, the Air Force Office of Scientific Research, and the pilots and crew members of the United States Air Force.

DEFINITIONS

1. CHANNELIZED ATTENTION - Focusing attention on a specific task at the expense of ignoring others of a higher or more immediate priority. Channelized attention is considered a factor when a pilot concentrates on the task being performed to the point that other cues of impending disaster are not noticed.

2. COMMAND AND CONTROL - Command and control is considered a factor when supervision is inadequate, or when operating procedures are inadequate, non-existent, or contradictory. Command and control deficiencies are normally characterized by inadequate supervision at unit or wing level, or inadequate mission planning or scheduling. Failure to monitor the conduct of operations, or failure to provide close in-flight supervision where training or proficiency are suspect are also indicators of command and control deficiencies.

3. DISCIPLINE BREAKDOWN - Discipline breakdown is evident when pilots willfully violate known directives or restrictions. Discipline is also considered a factor when pilots knowingly bend, stretch, or ignore restrictions because they perceive tacit approval by unit supervisors for the sake of mission accomplishment.

4. DISTRACTION - Interruption of focus of attention on a specific task by a non-task related sensory stimulus or mental process. Distraction is a factor when some unanticipated or unusual event or activity interferes with task performance.

5. EQUIPMENT MALFUNCTION - The failure or malfunction of equipment that is normally used in some phase of mission completion. This is a factor only when the failure or malfunction interferes with successful accomplishment of a task.

6. EVENT PROFICIENCY - The degree to which current training and practice were provided. Non-proficient is defined as : 1) the operator had never performed the task before, or 2) he had not performed it recently (within eight weeks), or 3) he performed it recently for the first time.

7. INADEQUATE BRIEFING - A premission meeting of crew members and immediate supervisors held for the purpose of outlining, planning and coordinating specific mission objectives, procedures and contingencies is a briefing. When a mission element that should have been briefed was not, or was inadequately briefed, briefing is considered a factor. Normal tasks, such as lowering the gear for landing, are not considered mandatory briefing items, and briefings are not considered inadequate when such tasks are not covered.

8. INADEQUATE TRAINING - Training deficiency is considered to be a factor when a pilot has no prior training, or was inadequately trained to perform the mission element being attempted.

9. LACK OF EXPERIENCE - Experience is considered a factor when a pilot does not have a sufficient background in the specific type of mission or type aircraft being flown, or in the crew responsibilities being performed. (Less than 200 hours in a specific role is considered lack of experience.)

10. LACK OF KNOWLEDGE - When a pilot was exposed to the information he needs to perform the mission element but did not absorb it, lack of knowledge is considered a factor. This assumes no deficiency in the training program provided.

11. MISSION STRESS - If the conditions surrounding a mission generate excessive stress, this is considered a factor. These conditions are often present during deployments, check rides, exercises, and other important missions.

12. OVERCOMMITMENT - The assignment of a task for which the operator is not prepared, or which in combination with other tasks, overtaxes his capacity. When a pilot chooses to perform a mission or is assigned to perform a mission element he is not capable of performing, he is said to be overcommitted. Overcommittment normally involves supervisor, schedulers, or flight leaders, but can also result from a lack of knowledge of his own limitations compared to mission demands, or in some cases from a combination of circumstances.

13. OVERMOTIVATION - Overmotivation is considered a factor when a pilot is predisposed to accomplish a given mission element successfully regardless of the situation. Mission success is afforded a higher priority than caution, judgement, or knownrestrictions.

14. PERSONAL STRESS - Personal stress may be a factor if a pilot has unusual or severe personal problems.

15. PRESSING - A pilot who continues speeific maneuvers or tasks to the point that known limits are exceeded is considered to be pressing or "taking a chance."

16. SKILL/TECHNIQUE - Skill or technique deficiencies are considered a factor when a pilot either lacks the required motor skills, or uses an improper technique to perform the task attempted.

CASE #1

FIGHTER (A-7D)

Midair collision. Flight of four A-7's on a normal training mission involving defensive maneuvers, as well as simulated range activities. The briefing called for number 4 to attack number 2, and number 3 to attack number 1. Aircraft number 4 began an attack on number 2. Number 3 tracked number 4, taking pictures, and during the picture-taking collided with number 4. The camera on board was owned by the pilot; it had been installed with a home-made bracket without the prior knowledge of the squadron supervisor. The pilot had been advised by one of the technicians that there were directives which prohibited using personal cameras in the aircraft. The A-7 does not have a camera for use in connection with air combat training or for recording air-to-air engagements. The camera in the accident aircraft blocked the forward visibility considerably and demanded constant pilot attention for operation.

Please circle the appropriate number after EACH "cause" below.

1. Definitely 2. Possible 3. Not Present

1.	Channelized Attention	1	2	3	9.	Lack of Experience	1	2	3
2.	Command and Control	1	2	3	10.	Lack of Knowledge	1	2	3
3.	Discipline Breakdown	1	2	3	11.	Mission Stress	1	2	3
4.	Distraction	1	2	3	12.	Overcommittment	1	2	3
5.	Equipment Malfunction	1	2	3	13.	Overmotivation	1	2	3
6.	Event Proficiency	1	2	3	14.	Personal Stress	1	2	3
7.	Inadequate Briefing	1	2	3	15.	Pressing	1	2	3
8.	Inadequate Training	1	2	3	16.	Skill/technique	1	2	3

Now that you have completed the previous pages, we would like to have your opinion of the degree to which you feel you understand the definitions contained in this form. Please indicate your impression by circling the appropriate number following each term.

1. Very clear 2. Somewhat clear 3. Very Vague

In the space under each definition please make any comments you wish about their usefulness.

1.	CHANNELIZED ATTENTION	1	2	3	9. LACK OF EXPERIENCE	1	2	3
2.	COMMAND AND CONTROL	1	2	3	10. LACK OF KNOWLEDGE	1	2	3
3.	DISCIPLINE BREAKDOWN	1	2	3	11 MISSION STRESS	1	2	3
4.	DISTRACTION	1	2	3	12. OVERCOMMITTMENT	1	2	3
5.	EQUIPMENT MALFUNCTION	1	2	3	13. OVERMOTIVATION	1	2	3
6.	EVENT PROFICIENCY	1	2	3	14. PERSONAL STRESS	1	2	3
7.	INADEQUATE BRIEFING	1	2	3	15. PRESSING	1	2	3
8.	INADEQUATE TRAINING	1	2	3	16. SKILL/TECHNIQUE	1	2	3